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By HGR, 11-28-52.

# RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

## EFFECTS OF WING FLAPS AND WING DUCT INLET ON THE LIFT AND STALLING CHARACTERISTICS OF A $\frac{1}{4}$-SCALE PARTIAL-SPAN MODEL OF THE REPUBLIC XF-12 AIRPLANE IN THE LANGLEY 19-FOOT PRESSURE TUNNEL

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By

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Langley Memorial Aeronautical Laboratory
Langley Field, Va.




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# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

November 18 1946

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# EFFECTS OF WING FLAPS AND WING DUCT INLET ON THE LIFT AND STALLING CHARACTERISTICS OF A $\frac{1}{4}$-SCALE PARTIAL-SPAN MODEL OF THE REPUBLIC XF-12 AIRPLANE IN THE LANGLEY 19-FOOT PRESSURE TUNNEL

By Robert R. Graham, Albert P. Martina, and Reino J. Salmi

## SUMMARY

An investigation was conducted in the Langley 19-foot pressure tunnel to determine the lift, drag, pitching-moment, and stalling characteristics of a $\frac{1}{4}$-scale partial-span model of the left wing of the Republic XF-12 airplane. The effects of a duct inlet, located between the nacelles at the leading edge of the wing, on those characteristics were also investigated. The Reynolds numbers for the investigation covered a range from 4,500,000 to 8,600,000.

The results of the investigation indicated that maximum lift coefficients of 1.36, 1.71, and 2.11 were measured on the model with flaps neutral and deflected 20° and 55°, respectively, at a Reynolds number of 8,600,000. When the duct inlet was replaced by a basic airfoil nose the flap-neutral maximum-lift coefficient was increased from 1.36 to 1.41. The results also showed that at maximum lift with flaps neutral or deflected 55° most of the area between the nacelles was stalled while only small areas on other portions of the model were stalled; when the duct inlet was replaced by the basic airfoil nose the stall was delayed to a slightly higher angle of attack but the nature of the stall was relatively unaffected.

## INTRODUCTION

The XF-12 is a high-speed, high altitude, long-range, photographic airplane designed by the Republic Aviation Corporation for the Army Air Forces. It is of conventional design and is powered by four Pratt and Whitney R-4360 engines. The overall dimensions and some of the details of the airplane are shown in figure 1. To aid in the design of the airplane, models of several components of the airplane as well as a model of the complete airplane were tested in various wind tunnels of the NACA Langley Laboratory.

A $\frac{1}{4}$-scale partial-span model of the left wing of the airplane was tested in the Langley 19-foot pressure tunnel for the primary purpose of determining the characteristics of a sealed internally balanced aileron similar to that intended for use on the full-scale airplane. The results of the aileron investigation were obtained at a Reynolds number of 8,600,000 and are reported in reference 1. The investigation also included a study of the lift, drag, pitching-moment, and stalling characteristics of the model with various flap deflections and the effects of a wing duct inlet on those characteristics. The results of the latter portion of the investigation were obtained at values of Reynolds number varying from 4,500,000 to 8,600,000 and are presented herein.

## SYMBOLS AND COEFFICIENTS

The symbols and coefficients used herein are defined as follows:

$C_L$ lift coefficient $(L/qS)$

$C_D$ drag coefficient $(D/qS)$

$C_Y$ lateral-force coefficient $(Y/qS)$

$C_m$ pitching-moment coefficient $(M/qc'S)$

$C_n$ yawing-moment coefficient $(N/qbS)$

$q$ free-stream dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$

$\rho$ mass density of air

$V$ velocity of air

$L$ lift

$D$ drag

$Y$ lateral force

$M$ pitching-moment about airplane center-of-gravity location ($0.2743c'$ on fuselage center line)

$N$ yawing moment about airplane center-of-gravity location

$S$ wing area

$c'$ wing mean aerodynamic chord

$b$ wing span

$\alpha$ angle of attack of root chord line

$\delta_f$ flap deflection

$R$ Reynolds number $(\rho V c'/\mu)$

$\mu$ coefficient of viscosity

$M$ Mach number $(V/a)$

$a$ velocity of sound

## MODEL AND APPARATUS

The $\frac{1}{4}$-scale partial-span model of the Republic XF-12 airplane represents the outboard 92.4 percent of the left wing of the airplane. The general dimensions of the model are shown in figure 2. The wing embodied Republic Aircraft Corporation airfoil sections designated as R-4, 40-318-1 at the root and R-4, 40-413-.6 at the tip. The ordinates are given in reference 2.

The model was tested in the Langley 19-foot pressure tunnel in conjunction with a reflection plane. A description of test methods with a reflection plane is given in reference 3. The general dimensions of the tunnel setup are shown in figure 3 and views of the model mounted in the tunnel are presented in figure 4. A gap of 3/16 ±1/32 inch was maintained between the inboard end of the model and the reflection plane by means of an automatic telescoping mechanism built into the model.

Partial-span double-slotted flaps were provided for the model and were held in place by brackets shaped to give the desired flap deflections of 0°, 20°, and 55°. Details of the flap are shown in figure 5.

An air inlet which was developed on the model in the Langley propeller-research tunnel was installed in the leading edge of the wing between the nacelles. The inlet was connected to ducts which represented the oil cooler, intercooler, and charge-air ducts of the airplane. The ducts had exits along the lower surfaces of both nacelles and were equipped with adjustable shutters for regulating the air flow through the ducts. The tests with flaps neutral were made with a duct shutter setting which gave an entrance velocity ratio of 0.41 at an angle of attack of 2°. The tests with flaps deflected 20° or 55° were made with a duct shutter setting which gave an entrance velocity ratio of 0.75 at an angle of attack of 8° with flaps neutral. For some of the tests the duct inlet was replaced by a solid nose piece which gave basic airfoil contour to that part of the wing between the nacelles. Details of the inlet and the airfoil nose are shown in figure 6. The ordinates for the inlet are presented in table I.

All tests reported herein were made with propellers removed and the cowl exit flaps set to simulate the airplane cruising condition. The model was equipped with a sealed internally balanced aileron which was kept at neutral for the present tests.

## TESTS

The tests reported herein were made in the Langley 19-foot pressure tunnel with the air in the tunnel compressed to approximately $2\frac{1}{4}$ atmospheres.

The lift, drag, and pitching-moment characteristics of the model were determined through a range of angle of attack with flaps neutral and deflected 20° and 55°. The data were determined at dynamic pressures of 25, 50, and 100 pounds per square foot corresponding to Reynolds numbers of 4,500,000, 6,300,000, and 8,600,000, and Mach numbers of 0.09, 0.12, and 0.17, respectively.

The stalling characteristics of the model were determined by observing the behavior of wool tufts fastened to the upper surface of the wing with cellulose tape. The stall tests were made, with flaps neutral and deflected 55°, at a Reynolds number of 8,600,000.

Some tests were made to determine the effects of the duct inlet on the lift, drag, and pitching-moment characteristics of the model with flaps neutral by testing the model through the same angle of attack range and Reynolds number range with the duct inlet replaced by the solid airfoil-contour nose piece. The effects of the duct inlet on the stalling characteristics of the model were obtained by repeating the stall tests with the duct inlet replaced by the basic airfoil nose.

## CORRECTIONS TO DATA

All force and moment data presented in this report have been reduced to nondimensional coefficient form. Moments were computed about a point corresponding to a center-of-gravity location on the center line of the airplane fuselage at 27.43 percent of the mean aerodynamic chord. Jet-boundary and plan-form corrections have been calculated and applied to the force and moment data by the method outlined in reference 3. Corrections were also applied for the absence of dihedral in the model by rotating the axes of the forces 6° (the amount of dihedral on the airplane) and correcting the projected wing area and span for the effects of the rotation. The final force and moment coefficients, therefore, apply to a complete wing with 6° dihedral. The total corrections applied are as follows:

$$C_L = C_{L_{gross}} - 0.1051C_{Y_{gross}}$$

$$C_D = 1.0055C_{D_{gross}} + 0.0154C_{L_{gross}}^{\ 2}$$

$$C_m = C_{m_{gross}} + 0.0087C_{L_{gross}} - 1.8685C_{n_{gross}}$$

$$\alpha = \alpha_{tunnel} + 1.003C_{L_{gross}}$$

where the subscript "gross" refers to the uncorrected coefficient.

No corrections for the tare and interference effects of the model supports were applied to the lift, drag, and pitching-moment

1947 7

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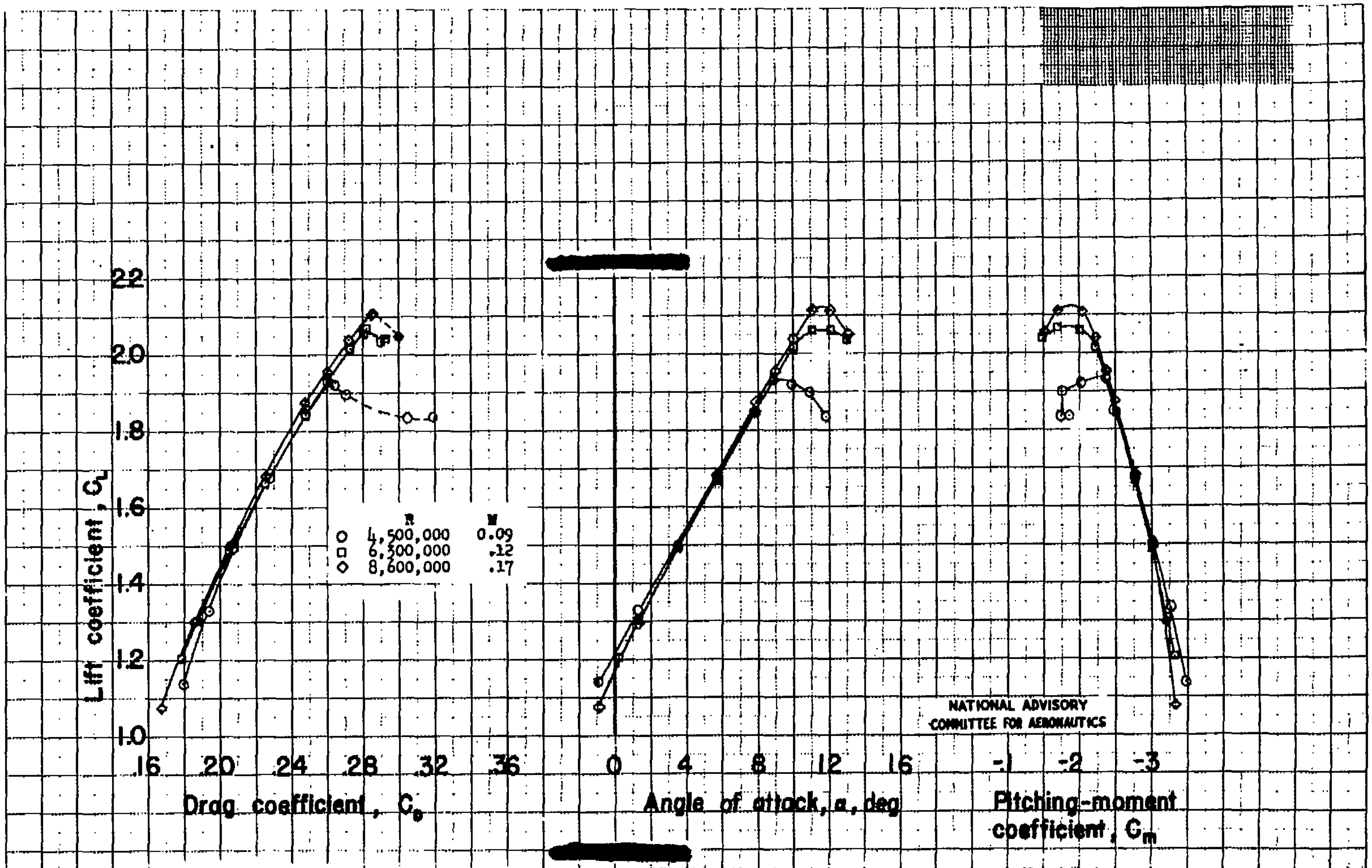


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(c) $\delta_f = 55^{\circ}$.

Figure 7.- Concluded.

## CONCLUSIONS

Tests of a $\frac{1}{4}$-scale partial-span model of the Republic XF-12 airplane in the Langley 19-foot pressure tunnel indicated the following conclusions:

1. Maximum lift coefficients of 1.36, 1.71, and 2.11, were measured on the model with flaps neutral and deflected 20° and 55°, respectively, at a Reynolds number of 8,600,000. When the wing duct inlet was replaced by a basic airfoil nose the flap-neutral maximum lift coefficient was increased to 1.41.

2. At maximum lift with flaps neutral or deflected 55° most of the area between the nacelles was stalled while only small areas on other portions of the model were stalled. When the duct inlet was replaced by the basic airfoil nose the stall was delayed to a slightly higher angle of attack, but the nature of the stall was relatively unaffected.

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CGB

## REFERENCES

1. Graham, Robert R., Martina, Albert P., and Salmi, Reino J.: Characteristics of a Sealed Internally Balanced Aileron from Tests of a $\frac{1}{4}$-Scale Partial-Span Model of the Republic XF-12 Airplane in the Langley 19-Foot Pressure Tunnel. NACA RM No. L6I18, Army Air Forces, 1946.

2. Klein, Milton M.: Aerodynamic Characteristics of Four Republic Airfoil Sections from Tests in Langley Two-Dimensional Low-Turbulence Tunnels. NACA MR. No. L5I19, Army Air Forces, 1945.

3. Sivells, James C., and Deters, Owen J.: Jet-Boundary and Plan-Form Corrections for Partial-Span Models with Reflection Plane, End Plate, or No End Plate in a Closed Circular Wind Tunnel. NACA TN No. 1077, 1946.

TABLE I.- ORDINATES FOR DUCT-INLET CONTOUR

(See figure 6 for explanation of symbols.)

[redacted]

| Inboard End | | | | | | Outboard End | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X (% c) | X (in.) | $Y_{u_o}$ (in.) | $Y_{u_i}$ (in.) | $Y_{l_i}$ (in.) | $Y_{l_o}$ (in.) | X (% c) | X (in.) | $Y_{u_o}$ (in.) | $Y_{u_i}$ (in.) | $Y_{l_i}$ (in.) | $Y_{l_o}$ (in.) |
| -2.01 | -0.900 | 0.030 | 0.030 | — | — | -2.01 | -0.791 | 0 | 0 | — | — |
| -1.99 | - .890 | .128 | - .043 | — | — | -1.99 | - .785 | 0.065 | -0.033 | — | — |
| -1.94 | - .870 | .208 | - .095 | — | — | -1.95 | - .770 | .162 | - .075 | — | — |
| -1.83 | - .820 | .323 | - .158 | — | — | -1.83 | - .720 | .293 | - .128 | — | — |
| -1.56 | - .700 | .512 | - .223 | — | — | -1.57 | - .620 | .438 | - .187 | — | — |
| - .89 | - .400 | .823 | - .250 | — | — | -1.02 | - .400 | .668 | - .216 | — | — |
| 0 | 0 | 1.142 | - .223 | — | — | 0 | 0 | .990 | - .190 | — | — |
| .46 | .205 | — | — | -1.820 | -1.820 | .46 | .180 | — | — | -1.543 | -1.543 |
| .49 | .218 | — | — | -1.748 | -1.940 | .49 | .192 | — | — | -1.482 | -1.645 |
| .54 | .241 | — | — | -1.695 | -1.975 | .54 | .212 | — | — | -1.437 | -1.678 |
| .74 | .330 | — | — | -1.590 | -2.073 | .74 | .290 | — | — | -1.348 | -1.757 |
| .89 | .400 | 1.402 | - .172 | — | — | 1.02 | .400 | 1.248 | - .138 | — | — |
| 1.04 | .465 | — | — | -1.492 | -2.172 | 1.04 | .409 | — | — | -1.265 | -1.841 |
| 1.44 | .644 | — | — | -1.404 | -2.270 | 1.44 | .566 | — | — | -1.190 | -1.925 |
| 1.94 | .868 | — | — | -1.325 | -2.360 | 1.94 | .763 | — | — | -1.123 | -2.011 |
| 2.68 | 1.200 | 1.845 | - .030 | — | — | 2.54 | 1.000 | 1.578 | - .035 | — | — |
| 2.94 | 1.317 | — | — | -1.216 | -2.500 | 2.94 | 1.157 | — | — | -1.031 | -2.125 |
| 3.94 | 1.765 | — | — | -1.140 | -2.602 | 3.81 | 1.500 | 1.802 | .059 | — | — |
| 4.46 | 2.000 | 2.198 | .118 | — | — | 3.94 | 1.551 | — | — | - .966 | -2.212 |
| 4.94 | 2.213 | — | — | -1.080 | -2.683 | 6.00 | 2.363 | — | — | - .875 | -2.319 |
| 6.69 | 3.000 | 2.568 | .303 | — | — | 6.35 | 2.500 | 2.162 | .248 | — | — |
| 7.00 | 3.138 | — | — | - .998 | -2.793 | 8.00 | 3.151 | — | — | - .837 | -2.380 |
| 8.92 | 4.000 | 2.878 | .489 | — | — | 8.89 | 3.500 | 2.448 | .436 | — | — |
| 9.00 | 4.035 | — | — | - .972 | -2.864 | 10.00 | 3.939 | — | — | - .818 | -2.420 |
| 12.00 | 5.380 | — | — | - .965 | -2.935 | 12.00 | 4.727 | — | — | - .801 | -2.450 |
| 13.38 | 6.000 | 3.387 | .859 | — | — | 13.00 | 5.120 | 2.875 | .742 | - .793 | -2.461 |
| 15.00 | 6.725 | — | — | - .958 | -2.988 | 14.47 | 5.700 | — | .852 | - .780 | — |
| 15.61 | 7.000 | 3.608 | 1.044 | — | — | 15.00 | 5.908 | 3.060 | — | — | -2.490 |
| 16.15 | 7.240 | — | — | - .955 | — | 15.74 | 6.200 | — | .965 | — | — |
| 16.28 | 7.300 | — | 1.100 | — | — | 16.00 | 6.302 | 3.141 | — | — | -2.500 |
| 16.51 | 7.400 | — | — | - .962 | — | 16.25 | 6.400 | — | — | - .821 | — |
| 16.96 | 7.605 | — | 1.179 | — | — | 17.25 | 6.793 | — | 1.156 | — | — |
| 17.14 | 7.685 | — | — | -1.000 | — | 17.43 | 6.865 | — | — | - .889 | -2.519 |
| 17.84 | 8.000 | 3.798* | — | — | — | 18.00 | 7.090 | 3.287* | — | — | — |
| 18.00 | 8.070 | — | — | — | -3.023* | 18.53 | 7.300 | — | — | — | -2.520* |

* Fairs into basic airfoil contour.

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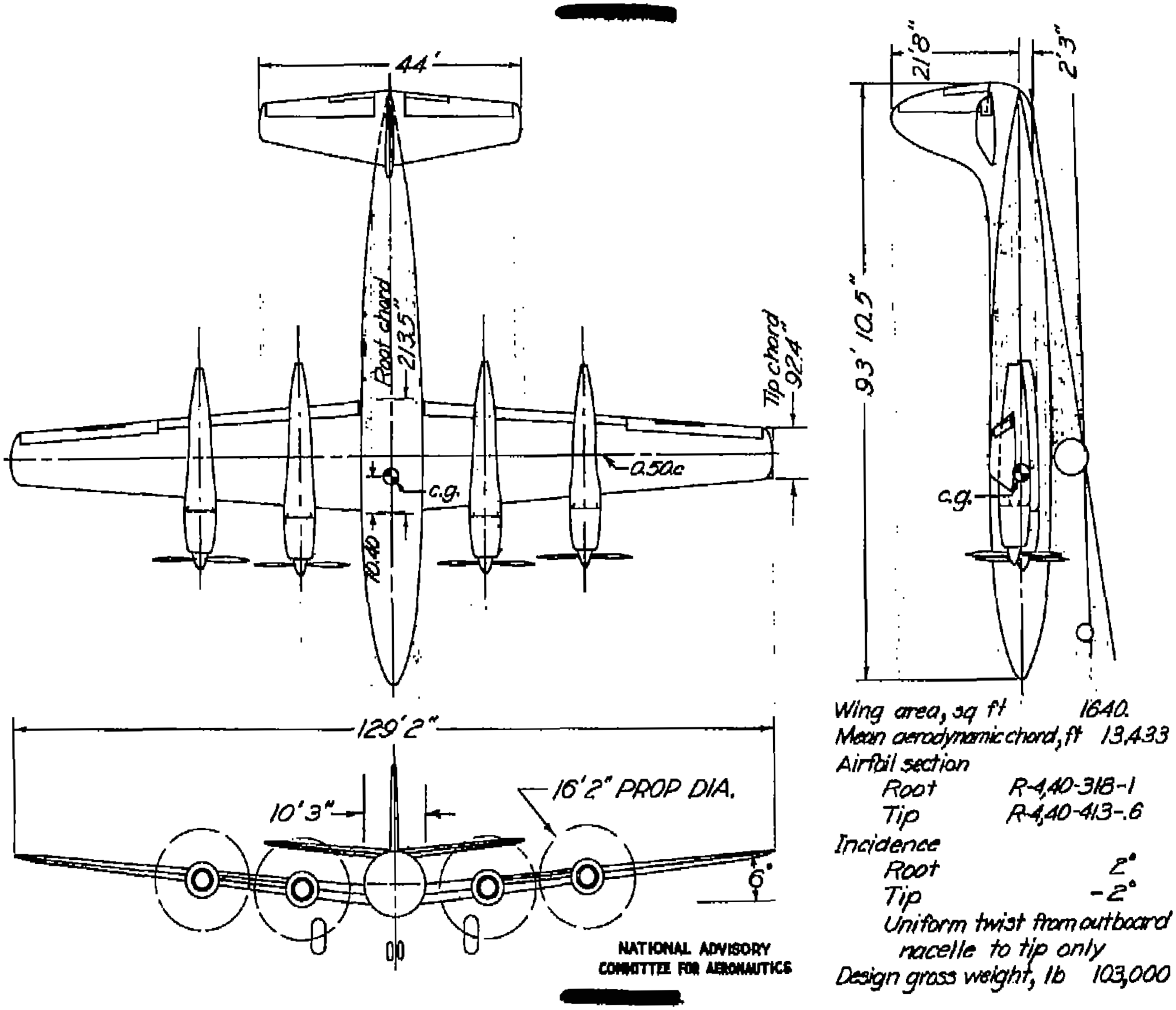


Figure 1.- Three-view drawing of the Republic XF-12 airplane.

[redacted]

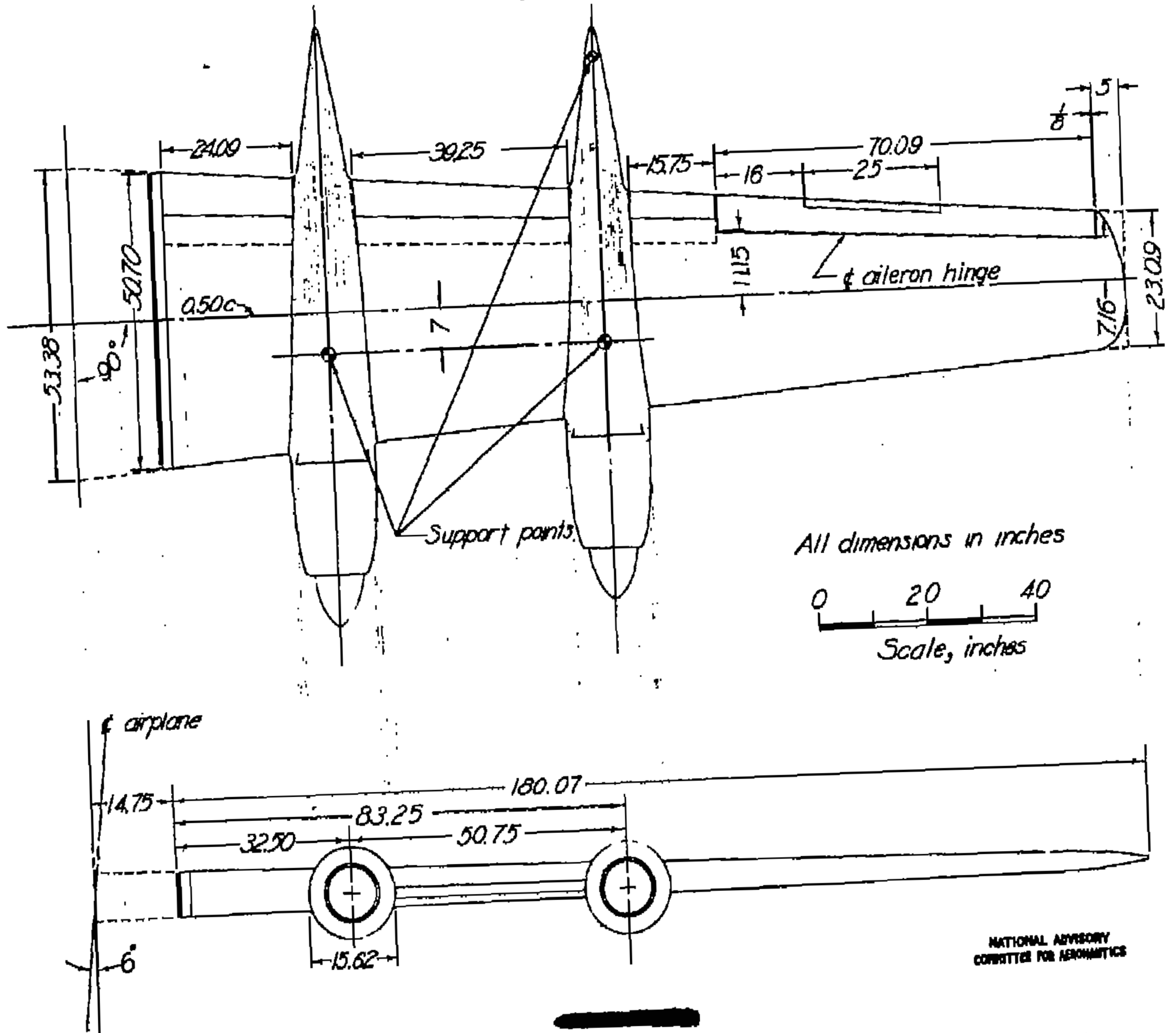


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Figure 2.- Plan and elevation of the $\frac{1}{4}$-scale partial-span model of the XF-12 airplane wing.

[redacted]

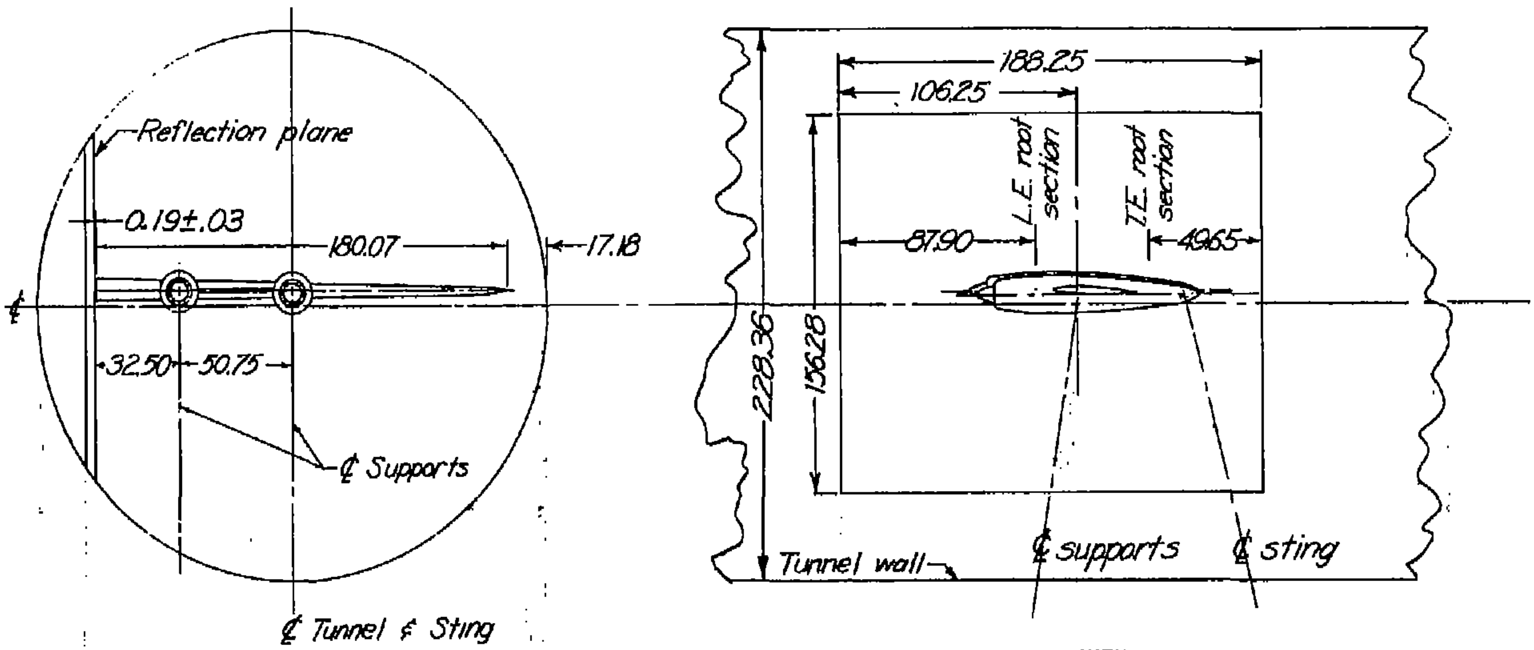


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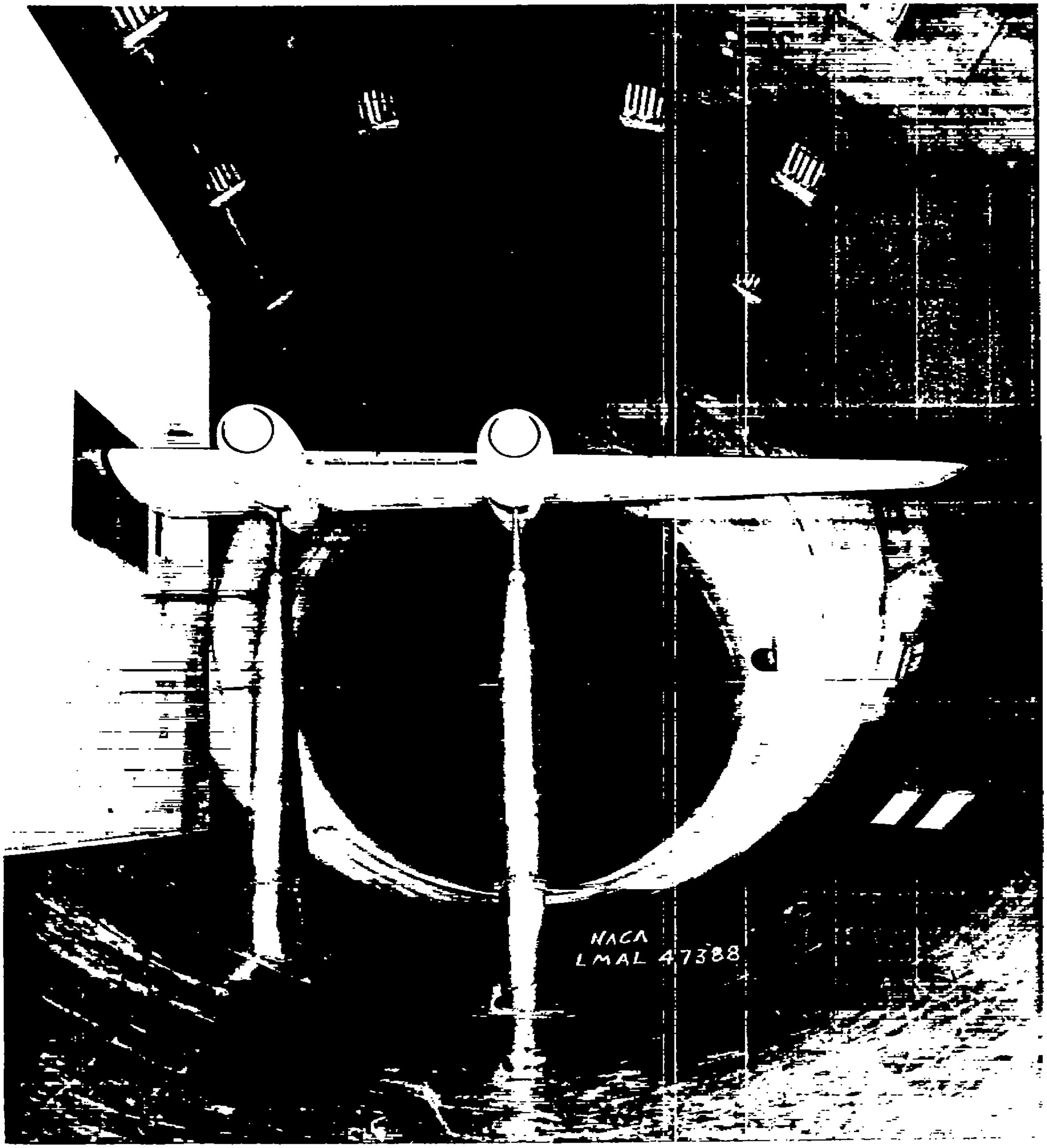
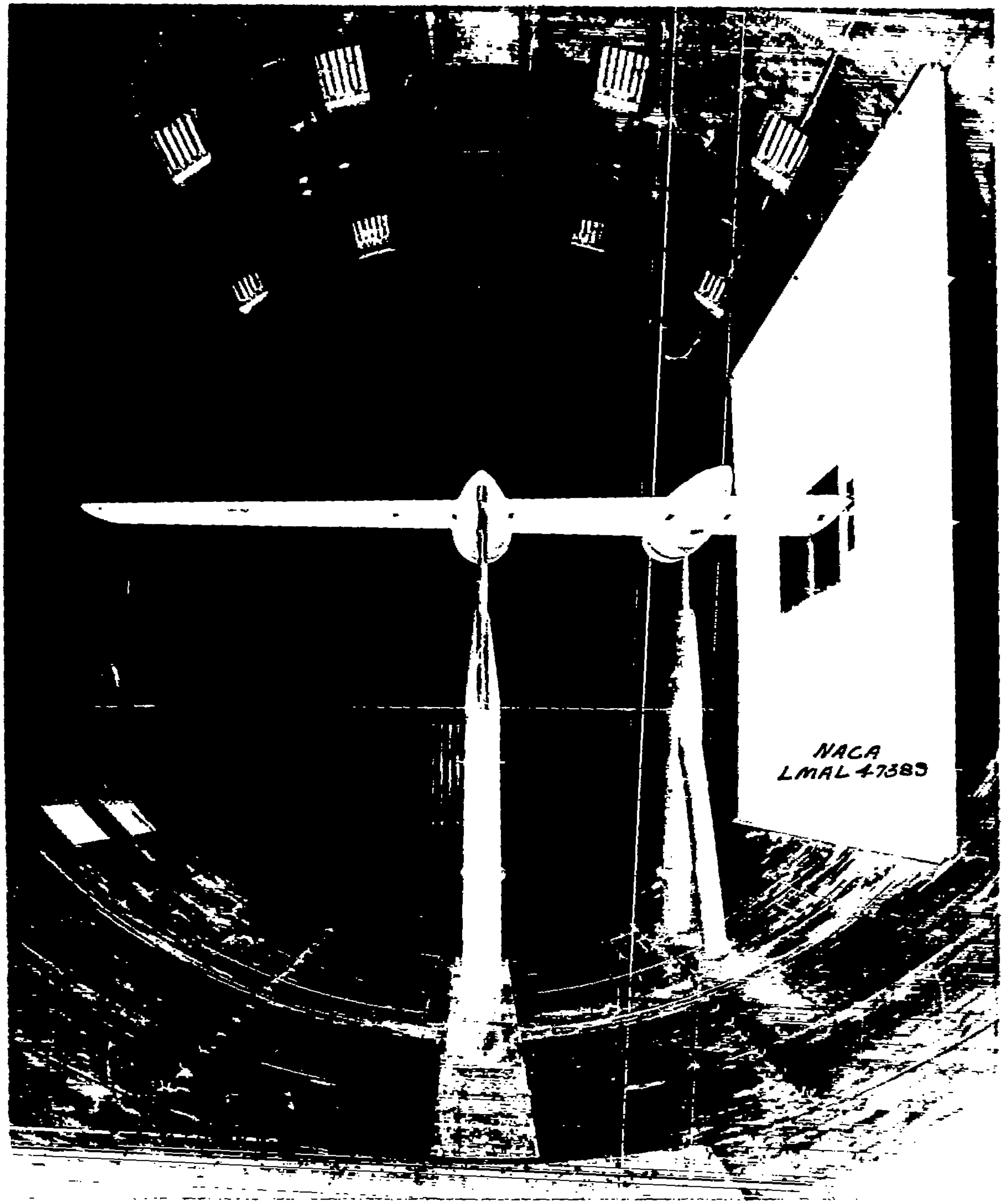
Figure 3.- Arrangement of the 1/4-scale XF-12 partial-span model and reflection plane in the Langley 19-foot pressure tunnel.




(a) Front view.

Figure 4.- 1/4-scale partial-span model of the XF-12 airplane in the Langley 19-foot pressure tunnel.

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(b) Rear view

Figure 4.- Concluded.

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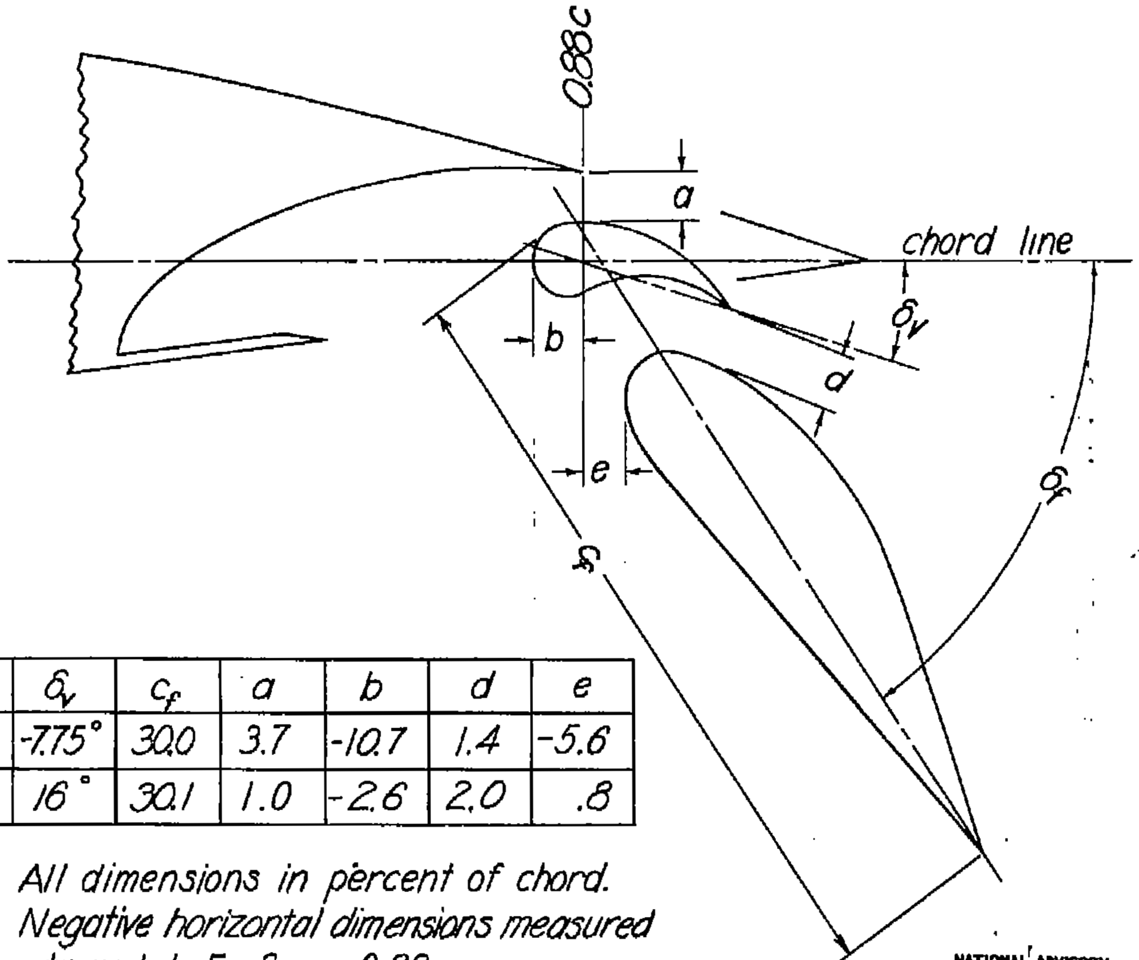



| $\delta_f$ | $\delta_v$ | $c_f$ | a | b | d | e |
|---|---|---|---|---|---|---|
| 20° | -7.75° | 30.0 | 3.7 | -10.7 | 1.4 | -5.6 |
| 55° | 16° | 30.1 | 1.0 | -2.6 | 2.0 | .8 |

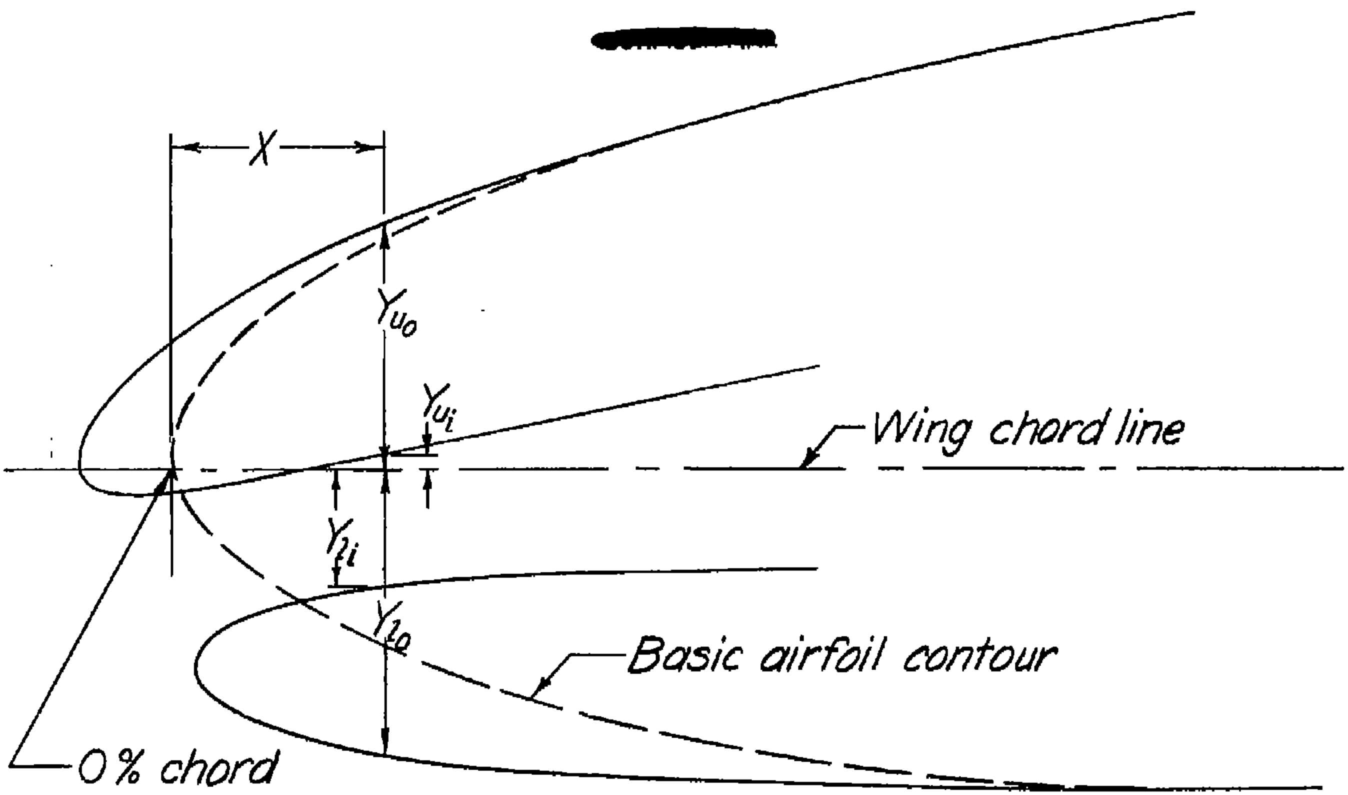
All dimensions in percent of chord.
Negative horizontal dimensions measured toward L.E. from 0.88c.



[redacted]

Figure 5.- Typical section of double-slotted flaps on the 1/4-scale partial-span model of the Republic XF-12 airplane.

[redacted]




See table I for ordinates of inlet.

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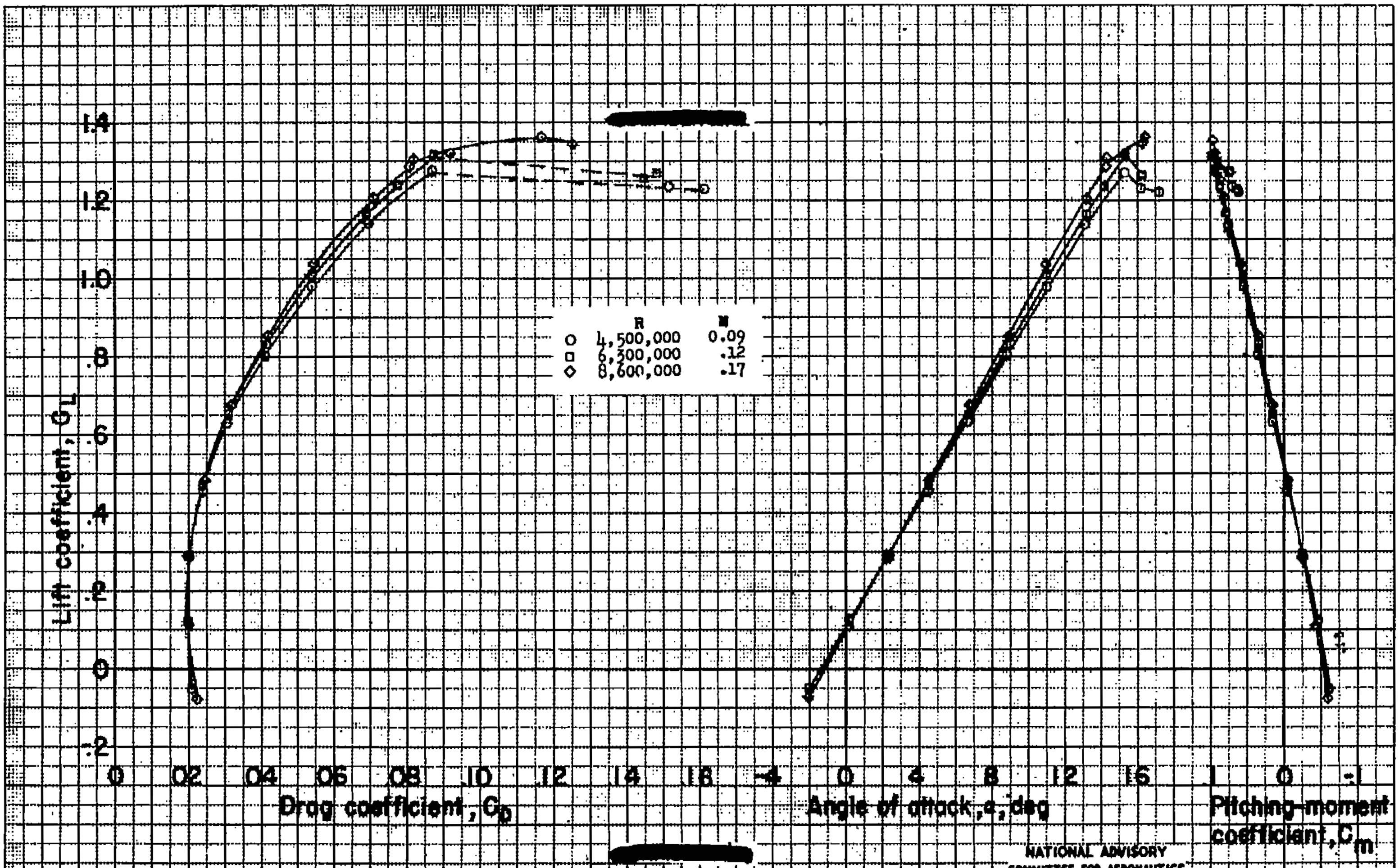
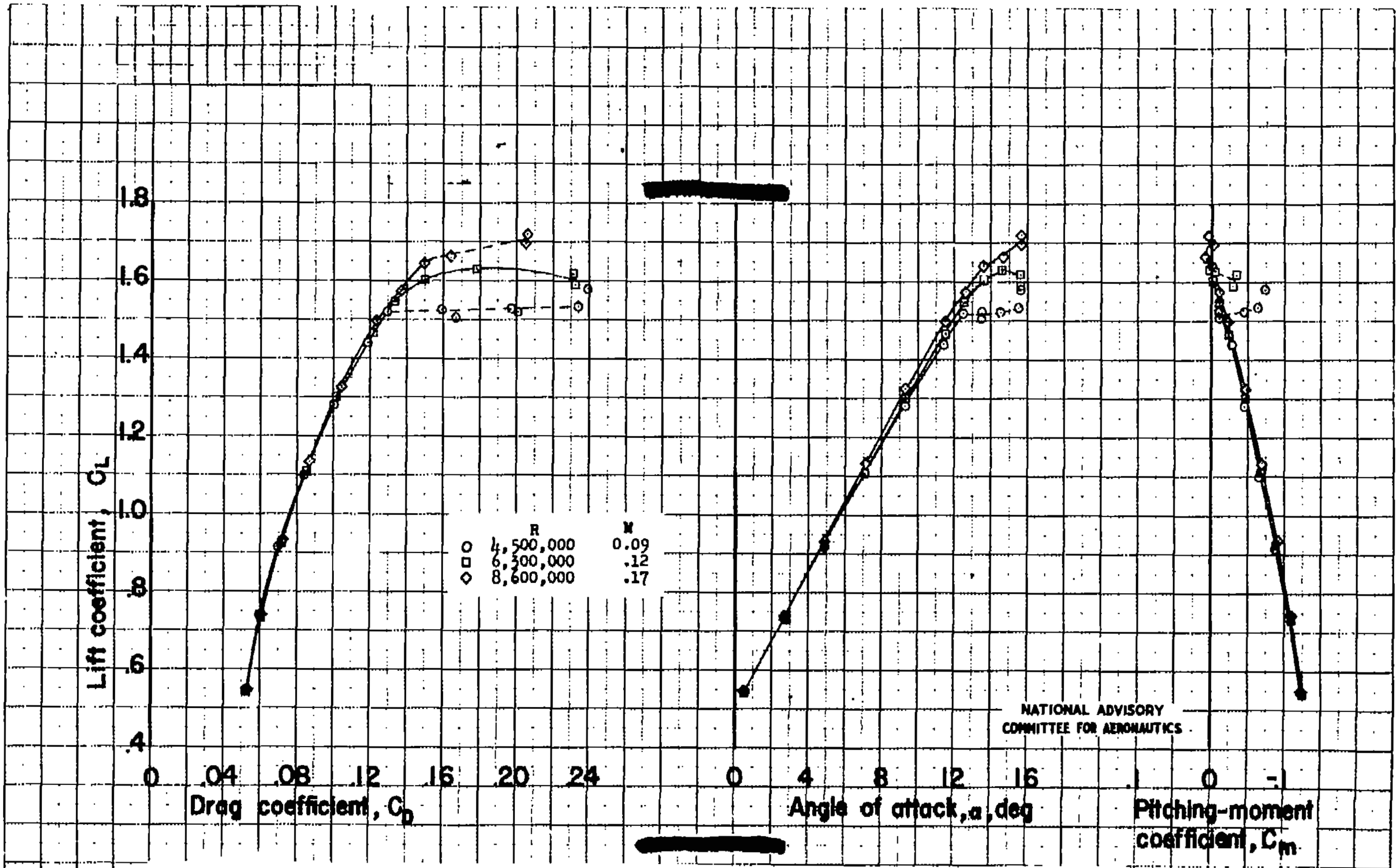
Figure 6.-Typical section of wing duct inlet and basic airfoil nose on $\frac{1}{4}$-scale partial-span model of XF-12 airplane.




(a) $\delta_f = 0^\circ$.

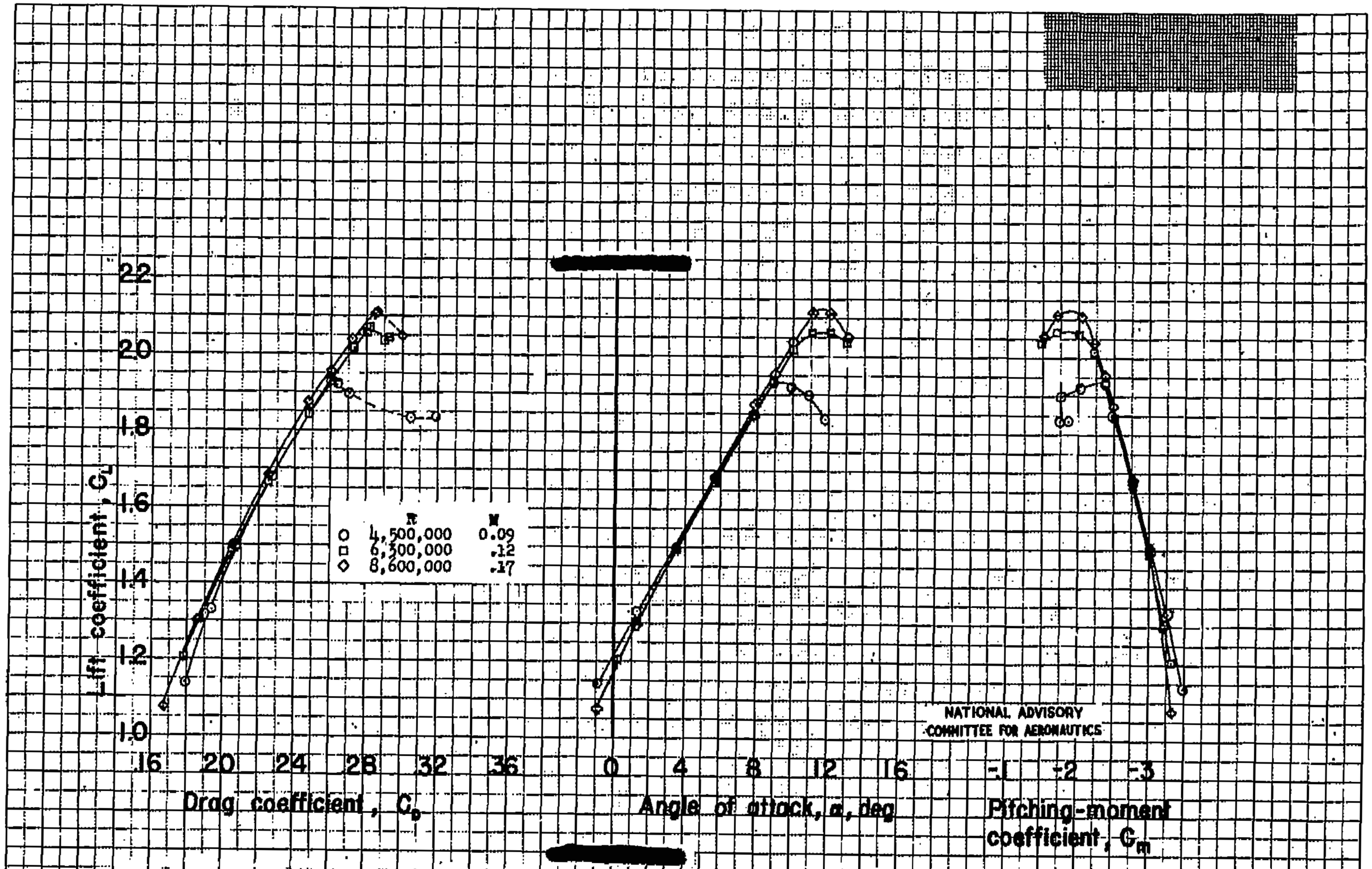
Figure 7.- Aerodynamic characteristics of 1/4-scale partial-span model of the XF-12 airplane with wing duct inlet.




(b) $\delta_f = 20^{\circ}$.

Figure 7.- Continued.

[redacted]

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(c) $\delta_f = 55°$.

Figure 7.- Concluded.

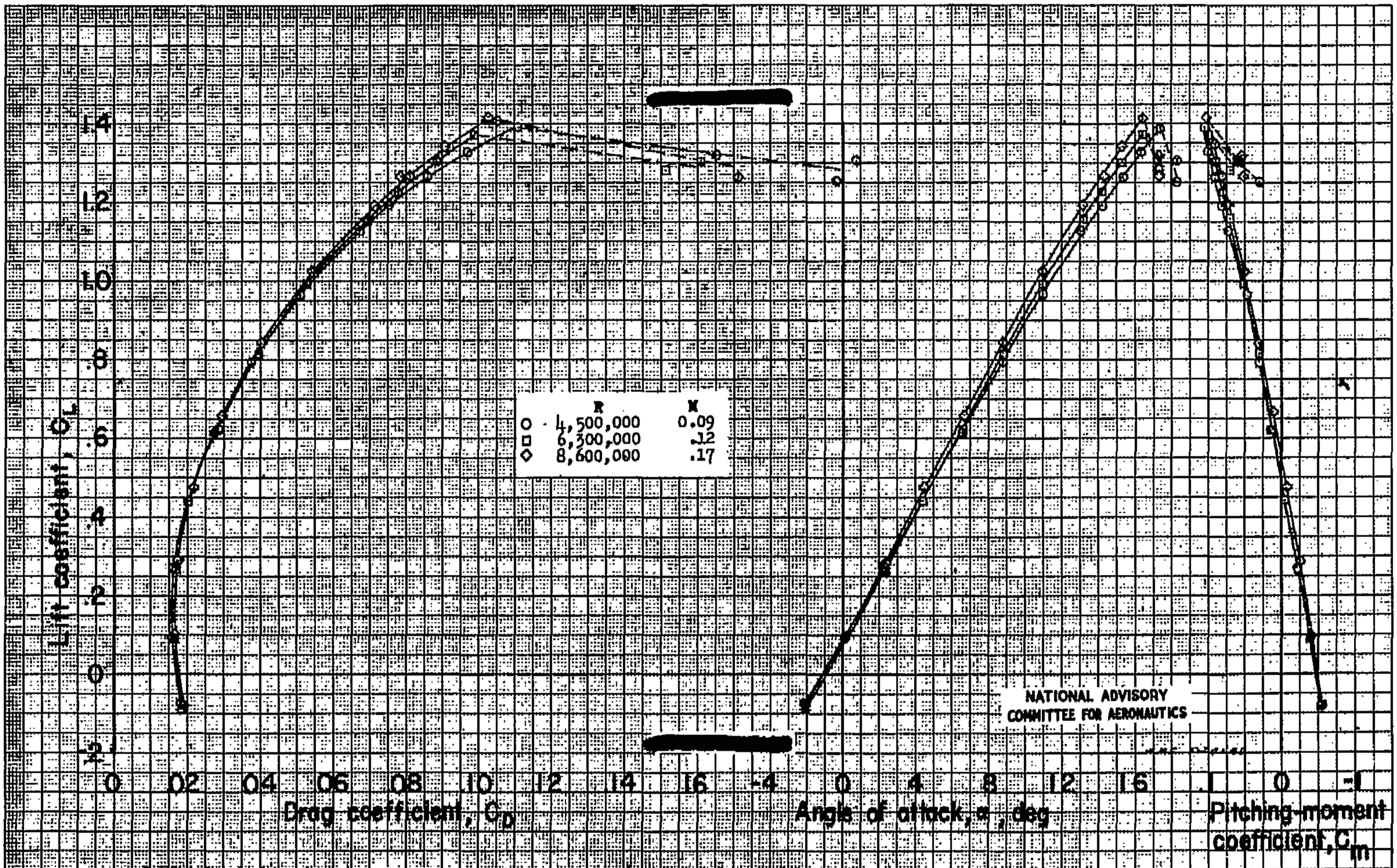
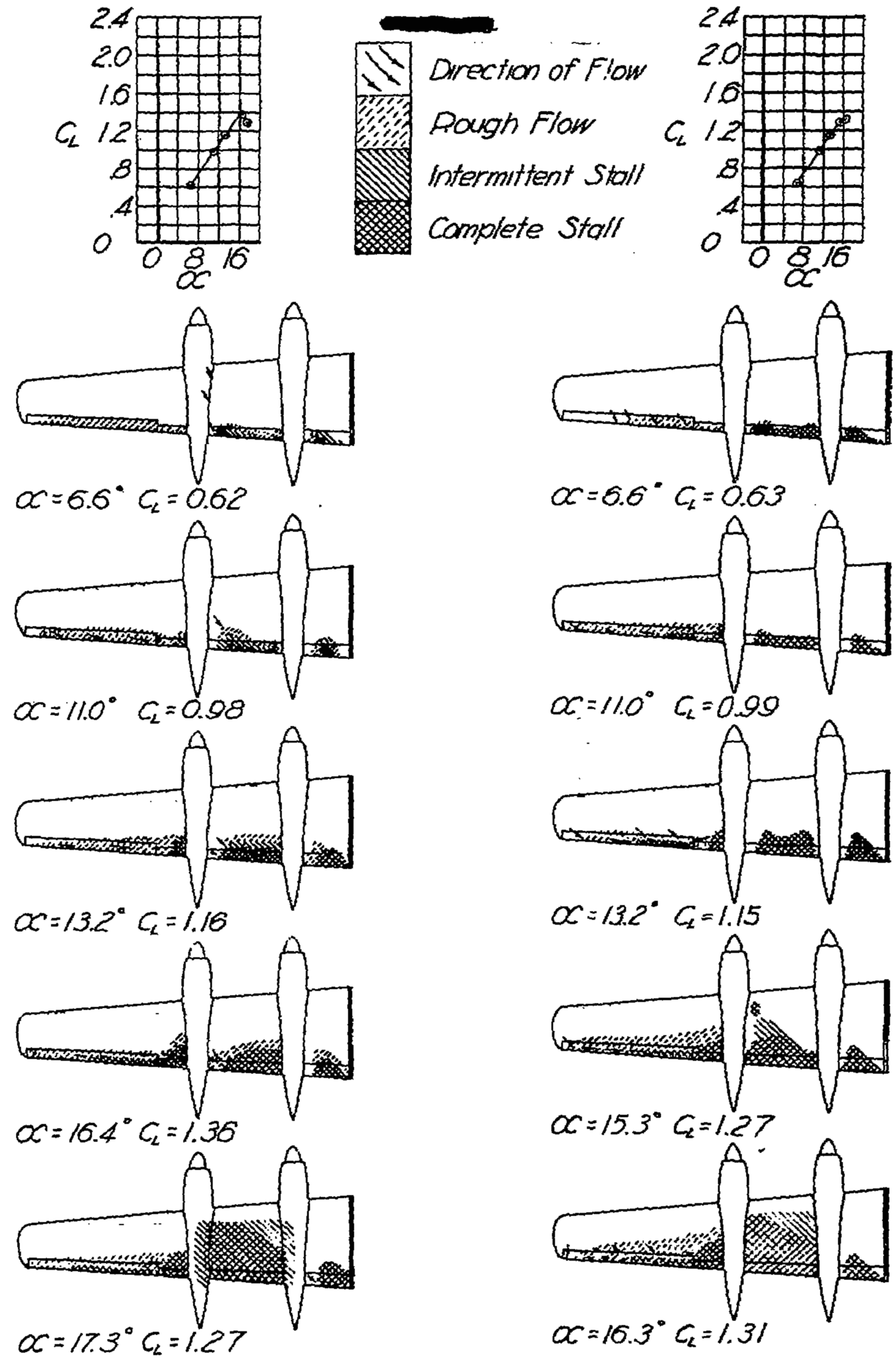



Figure 8.- Aerodynamic characteristics of 1/4-scale partial-span model of the XF-12 airplane with basic airfoil nose. $\delta_f = 0^\circ$.




(a) Basic airfoil nose; $\delta_f$=0° [redacted] (b) Wing duct inlet; $\delta_f$=0°

Figure 9.-Stalling characteristics of $\frac{1}{4}$-scale partial-span model of the XF-12 airplane. R=8,600,000.

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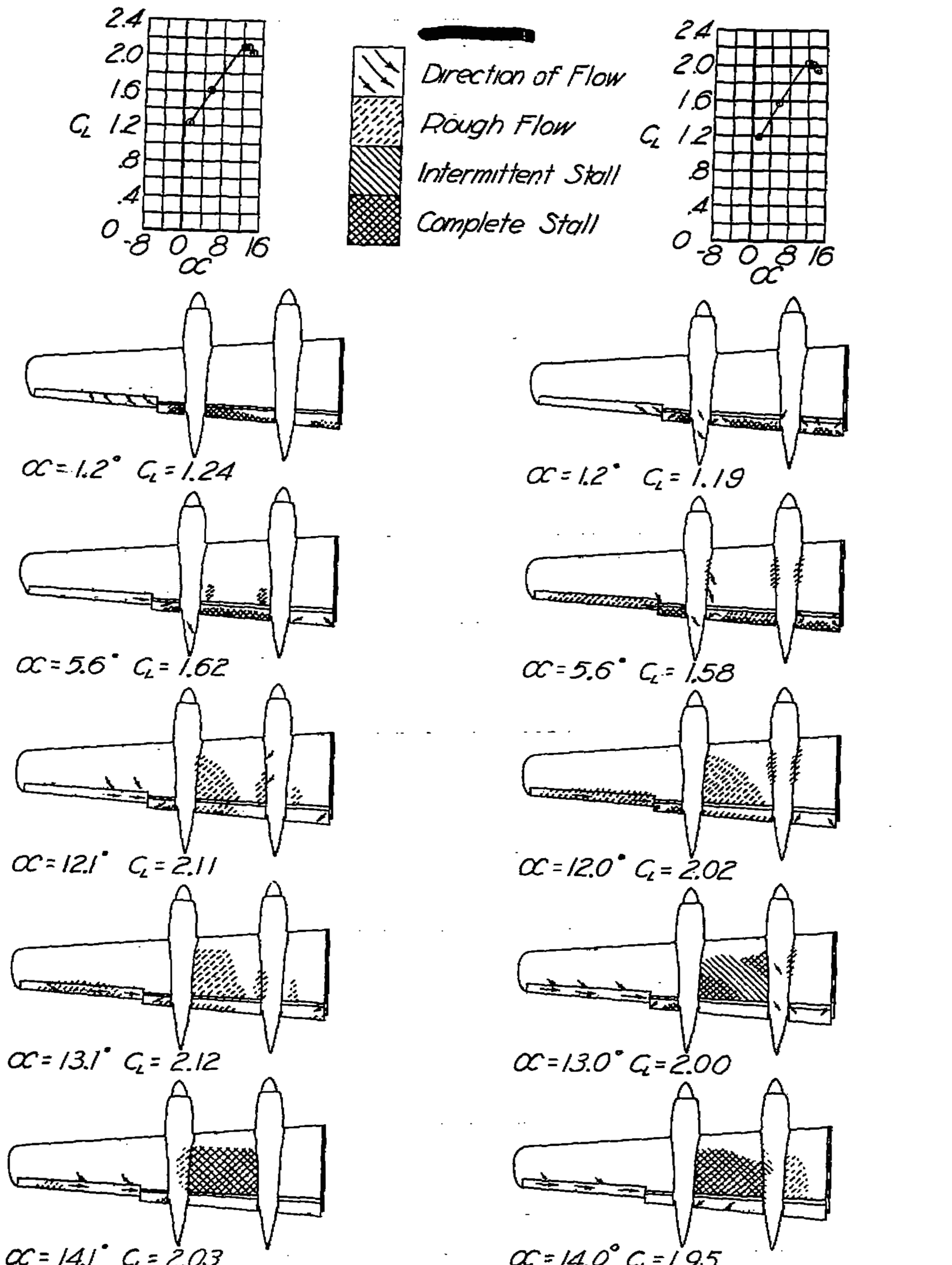


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(c) Basic airfoil nose; $\delta_f = 55°$

(d) Wing duct inlet; $\delta_f = 55°$



Figure 9.- Concluded.